SCIENCE

NEW YORK, OCTOBER 21, 1892.

THE CAUSES OF INFECTIOUS DISEASES.

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THE real causes producing infectious diseases were unknown until the present era. Preventive treatment, where it existed, was based upon empirical observations; and, although the idea of a *contagium vivum* was conceived a hundred years ago, the possibility of a tangible demonstration of the destructive agent underlying all those zymotic diseases which have so often decimated mankind and wiped whole communities from the face of the earth was scarcely dreamed of a few decades since.

To-day medicine may truthfully be called the benefactrix of the human race; and, though we are but on the threshold of the new era, yet enough has been already achieved to prove of eminent value to humanity. Only twenty years ago who would have thought it possible that so dreaded an epidemic as the Asiatic cholera could be prevented from entering a country whose borders it had reached, and that the fatal malady when it had once found victims in a populous city could be limited to the imported cases attacked, and its further progress be halted? Here we had cholera at our very doors; but it could not enter, and a whole continent has escaped its deadly visit. In such great centres of human industry as New York and Berlin, where thousands of strangers daily arrive and depart, a few cases occurred, but the ghastly disease was driven off without its being able to select one more victim!

Such facts prove the value of the achievements of modern medicine, and clearly show the immense progress this science has made. The question naturally occurs to the intelligent mind — how was it possible to achieve what but recently has seemed unattainable? And the answer is — because of the knowledge gained by bacteriology, this new but all-important branch of modern pathology!

Let us glance at the recent discoveries and bring before our mental eye the principles underlying the study of infectious diseases. At the boundary of the animal and vegetable kingdoms there is an immense empire of beings so minute that the naked eye cannot see them, and that the most powerful microscope alone does not suffice to determine the various species. So difficult becomes here the recognition of the individual that for years the most eminent authorities were in doubt how to classify these minute organisms. Are they animals or plants? The weight of testimony has at last decided in favor of the empire of plants. To it belong these micro-organisms, of which millions weigh but one grain, but which have the power of multiplying at such an extraordinary degree that, as Cohnheim has calculated, the breed of bacteria springing from one germ about $\frac{1}{500}$ of a millimeter in length and $\frac{1}{1000}$ of a millimeter in thickness, provided the development and multiplication could go on without hindrance, within less than five days would completely fill all the oceans of the earth, and the descendants of one single micrococcus, whose weight is so little that sixteen hundred millions of them weigh but one grain, would within three days reach the enormous weight of fifteen million pounds! But fortunately nature has placed impediments in their way; they can develop only under certain favorable conditions, otherwise how soon would these diminutive little beings overpower every living organism!

There are two great subdivisions of these microbes, hyphomyceti and schizomyceti. The first, so-called moulds or fungi, multiplying mainly by the aid of spores, are parasites, among which are many that give rise to diseases of the skin and mucous membrane, as favus, thrush, etc. The propagation of the second class — schizomyceti — takes place mainly by division. Most of them have a rod-like form. The Greek word for rod is βακτήριον; hence the term bacterium. But not all have the same shape, and according to their forms they are arranged in six classes: —

1. Micrococci, or cocci, with circular shape.
2. Bacilli, including all rod-shaped bacteria, short or long.
3. Bacteria proper, as which science recognizes only the shortest bacilli.
4. Vibriones, rods of wavy shape.
5. Spirilli, forming short, stiff screws.
6. Spirochaeti, having the form of long, flexible screws.

Modern research with positive certainty has demonstrated the fact that the activity of bacteria is not limited to the production of one kind of processes. While many of them never prey upon the human organism, others are pathogenic, i.e., disease producing; but the first condition necessary to their development is their entrance into the living human or animal body. One class of schizomyceti, the so-called septic bacteria, at once begin their enormous propagation, when death has interrupted the mechanism of life and the organized tissue having ceased all motion is decomposed, decays, ferments, and putrefies. To-day it is a recognized fact, undisputed by any authority, that the process of putrefaction by which the dead organized tissue returns its constituent parts to the inorganic world and thus completes the never-ending circle, is caused by the septic microbes alone. Without them there can be no decay. All our disinfectants, our processes of embalming, our methods of preserving organic substances by complete exclusion of air, are based upon one principle — preventing the development of septic bacteria.

Another kind of these minute organisms gives rise to various chemical changes known as fermentations. The process by which sugar is changed to alcohol and carbonic acid is due to the yeast-plant; when fermented fluids become acid, this change to the vinegar fermentation is caused by another bacterium; that milk turns sour a rod-shaped schizomycete is responsible for; the discolorations noticed on potatoes, cheese, boiled eggs, etc., as well as the blueish and yellowish tint sometimes assumed by milk, and the green and blue color of pus, are produced by bacteria. The remarkable incident which has caused so much religious superstition, viz., that on the holy wafer appeared a drop of blood, simply depends upon decomposition induced by a micrococcus (*Monades prodigiosœ*, Ehrenberg), and is met with also in unleavened bread.

But bacteria do not cause only the decomposition of *dead* organic substances, they extend their fiendish power also to the destruction of the processes of life of the highest organized beings — the human race and the animals nearest to it.

It would lead me here too far to narrate how the discovery was made, and how by patient research and logical reasoning science has at last succeeded in determining the true cause of infectious disease. Suffice it to say that every zymotic malady — be it acute, like cholera, pneumonia, typhoid fever, small-pox, chicken-pox, scarlet-fever, measles, whooping-cough, yellow-fever, intermittent or remittent fever, cerebro-spinal fever, erysipelas, diphtheria, etc., or chronic, like tubercular consumption, cancer, chronic malaria, lupus, etc. — is due to some special micro-organism, which during the process of development and multiplication in the human (animal) tissues gives rise to the formation of ptomaïnes, — highly organized and most virulent poisons, — which in their turn produce the phenomena, the group of symptoms, that characterize an infectious disease. And the more active this process of development, the greater the number of the bacteria introduced into the living organism, the more favorable the soil presented to them, the more virulent is the ptomaïne, the

more overwhelming the effect! We thus have an explanation of the fact often observed that at the beginning of some epidemics, especially of such grave maladies as yellow-fever, typhus, Asiatic cholera, etc., the victims seized by them frequently die within less than an hour after the first symptom has indicated the outbreak of the disease.

How difficult, however, bacteriological investigations are may be judged from the following data. Some of the pathogenic bacteria resemble each other so greatly that the microscope alone, however powerful, does not suffice for their recognition. In such cases the suspicious microbes are exposed to the influence of various coloring processes; and, as each species evinces a behavior different from that of another variety, the result of the coloring tests often leads to the recognition of the species. But even that does not satisfy the modern bacteriologist. Pure-culture and experimental research must be added. After all the microbes present in a diseased tissue have been removed, they are spread over a layer of beef-tea gelatine, where their development is watched under the microscope. If there are several species — suppose three, though there may be many more — it is soon found that on three different spots of the gelatine certain changes are going on. While in one spot a peculiar excrescence has formed, in another a cup-shaped depression is noticed with the gelatine near it dried, and in the third the shape observed is still different and the gelatine surrounding this spot has become more fluid. From these various behaviors the expert can probably recognize which of the three species is the pathogenic one for which he is looking. Certainly in all these researches care must be taken that no other micro-organism can enter the receptacle in which the developments are progressing; and, as the atmosphere constantly contains many kinds of microbes, the reader may have some conception of the difficulties presenting themselves.

After the suspicious species has been recognized on the gelatine soil, a minute particle is taken from that particular spot, and carried to another culture-soil, which may again be some bouillon gelatine, or agar-agar, or a potatoe-skin, or blood-serum, or any similar substance. It may also be noted that the different species evince a natural preference for some soil, while they obtain only a stunted growth in others.

In all these processes every instrument used must be aseptic, i.e., free from bacteria. Under the precautions mentioned the development of the micro-organisms selected from the one spot and transferred to a special culture-soil is again carefully noted, and if the phenomena accompanying the multiplication and maturing in this pure culture correspond with those known as characteristic of the species in question—in the case of an unknown species these characteristics must first be elucidated by special observations — then the experimental stage is entered. A minute particle of the result of the last pure culture is introduced into some animal organism, and if there it gives rise to the lesions and symptoms of the same infectious disease as that in which the bacteria had first been met with, and if later the specific bacteria taken from the blood or tissues of the inoculated and infected animal again behave under pure culture as the original species did, the proof is considered final and complete, and the microbe in question is recognized as the pathogenic element of the particular infectious disease in which it was found.

To illustrate, the sputum of patients suffering from tubercular consumption contains other bacteria besides the tubercle bacilli — the real cause of the fatal malady. A microscopical examination even with the application of some color-tests, while for practical purposes easily concluded and sufficient, if necessary to be done with scientific exactness does not answer every demand; because the species causing glanders, the fatal disease of horses, that of tubercle, of anthrax, and of cholera, at some time or other, have nearly the same shape. One appears a little thicker, another more rounded at one point, a third slightly longer; but, if we remember their minute size, we may imagine how slight the difference must be when one is an immeasurable bit smaller or thicker. In this instance other color-tests aid the expert; for, while the bacilli of glanders take on the coloring without difficulty, those of tubercle and of anthrax have to be exposed to its influence a considerable time. Then the bacilli of anthrax, after the staining, easily yield the color to the influence of acids, but those of tubercle resist the action even of sulphuric acid, while the comma bacilli of cholera soon develop other peculiar characteristics.

Sputa containing the tubercle bacilli were dried, mixed with street-dirt, exposed for months to all kinds of weather, again dried, and finally used for the following purpose. Two small brick houses were erected in Paris some miles apart, and into each one dozen healthy rabbits — A and B — were placed, which all received the same food, water, treatment, and attention with this difference: into the building containing the rabbits A some of the sputum-dust referred to was thrown daily for a week by the aid of a pair of bellows, so as to mix with the air in the room. About six weeks later all these rabbits had died of galloping consumption, while the rabbits B remained in excellent health.

A bacteriological examination showed the presence of the tubercle bacilli in large numbers in the tissues of the dead rabbits. Some of these bacteria, taken for pure culture, were later again introduced into the tissues of other animals, and again caused the outbreak of consumption in them and their final death.

The specific microbes of a great number of infectious diseases have been discovered, while in others the investigations are still being carried on. For the purpose of diagnosis this discovery is of the utmost import, as the presence of the specific microbes in any disease at once determines the true nature of the latter. Then by a careful study of the conditions of development of these bacteria valuable information has been gained, which has proved useful for the purposes of prevention. Thus in consumption we know, if the sputa of tuberculous patients are destroyed, and if the milk and flesh of animals suspected to be afflicted with the disease are thoroughly boiled, that the danger of infection from them disappears. In the same way we have learned that the germs of cholera are not propagated by the atmosphere, but that they must be swallowed to penetrate into the intestines where alone they can mature, multiply, and produce the disease. The knowledge of these facts enables us to prevent the spreading of the epidemic.

A study of the behavior of the bacteria of decomposition has led to the application of modern asepsis in surgery. A wound that is thoroughly impregnated with a disinfectant, i.e., with a remedy which destroys all such microbes, need only be protected against further contamination to insure its healing by first intention, meaning without the development of pus. Many serious operations which were indicated and which would have saved life years ago, while not presenting in their execution special difficulties to the experienced surgeon, could not be performed because the immense pus-discharge which would have followed them would have proved exhausting, and have brought about the death of the patient. Thus it was with operations on large joints, with injuries affecting the abdominal organs, and with lesions of some of the serous membranes, as the pleura, etc. To-day these operations are performed under the strictest aseptic precautions; the hands of the operator and those of his assistants, every instrument and appliance to be used, the external surface above the seat of the parts to be operated upon — all are disinfected and kept free from bacteria. The operation ended and the bleeding arteries secured with aseptic catgut, which is later absorbed, the parts concerned are completely disinfected and the dressing applied, which, impregnated with material that would prove destructive to any micro-organism entering it, is also calculated to exclude the atmosphere. The result is surprising. In many of the most serious operations, those on the brain included, the dressing often is not renewed but allowed to remain for a week or longer, and when finally taken off the parts underneath are found to have healed without a drop of pus having ever been present and without the temperature of the patient having ever ascended above normal, thus demonstrating the absence of all wound-fever, once so dreaded. Hospital gangrene, erysipelas, and puerpural-fever to-day are almost unknown. And this remarkable achievement is due solely to the results of bacteriological studies!

At the present time the most prominent investigators, the celebrated Koch in Berlin at their head, are endeavoring to find the proper remedies with which to antagonize the action of pathogenic bacteria. They are trying to discover a ptomaïne which

will neutralize the effect of the pathogenic ptomaïne producing each infectious disease. To relate here the details would carry us too far into the domain of organic chemistry. I may indicate, however, one other method, which, while having the same object in view, promises great success. Take, for instance, tubercular consumption. There are some animals that cannot be inoculated with the tubercle bacilli, because they are protected by nature against them. The question is, What substance in the blood — we believe it to be in the blood serum, that part of the blood which remains after the removal of the red and white corpuscles — of these animals prevents the development of the tubercular malady? If that substance can be isolated, the victory is won. Koch has taken some of the blood serum of an animal thus protected, and by transfusion brought it into the circulation of an animal specially predisposed to and inoculated with the disease. He succeeded in thus greatly diminishing the severity of the latter.

Professor Lister, on returning from his last visit to Koch in Berlin, said to the English physicians listening to his report, among other things, the following: "But while my lips are sealed with reference to the details, that much may I say, that before a few more years are passed the world will stand aghast at the discoveries made in Berlin. I have seen rats in the agony of lock-jaw, after the subcutaneous injection of a drop of fluid, within a few hours run about in perfect health!"

We are undoubtedly on the threshold of a new era, on the eve of a revolution, the greatest medical science has ever seen. The morning of a bright future has dawned; the light is ascending the horizon, and will soon shed its lustre from the meridian!

HOW TO MOUNT BIRDS WITHOUT REMOVING THE SKELETON.

BY ULYSSES O. COX.

To some, no doubt, it will seem useless to attempt to mount more than the skin of a bird; but, having had some experience with both methods, I wish to state what has been my success with the new one. The process is about the same that has been described by others, but the soap preservative is my own invention.

A pair of pointed scissors, scalpel, tenaculum hook, file, wire-cutters, several hooks of different sizes made of stiff wire, two pairs of forceps, one of the ordinary style and another with about one-eighth of an inch of each point bent out at right angles, are the tools that should be at hand. A dry poison should be prepared of one part arsenic and one part powdered alum. An arsenical soap should be made as follows:—

Group one.

Dry arsenic,	2oz.
Cake soap, any good,	2oz.
Potassium carbonate,	½oz.
Air-slaked lime, sifted,	½oz.

Group two.

Corrosive sublimate,	2dms.
Cyanide of potassium,	2dms.

Two or three moth balls, or one dram of camphor.

Put the first group in a vessel with enough water to dissolve it to the consistency of thick cream. Heat and stir until thoroughly dissolved. Dissolve the second group in another vessel in cold water, and when the first group is about cold stir in the second. Put the soap in well-corked bottles or cans. The cyanide of potassium, moth balls, and camphor, are not used for their preservative properties but to insure the specimens against moths or other insects.

A quantity of cotton, tow, wire of different sizes, and plaster of Paris should be at hand. For trial, select a medium-sized bird, say a jay or a robin, and clean off all dirt and blood-spots by first washing in clean water then drying with plaster of Paris. With the tenaculum hook catch the white coat of the eyeball and with a gentle pull remove the eye. Wipe the socket dry. Remove the other ball in the same way. With a wire, punch through the skull in the back part of each eye-socket and stir up the brain well. Fill the eye-socket with the dry preservative and stir it into the brain cavity. If careful, the brain can be so well poisoned thus that it will dry nicely. Fill the eye-sockets with cotton and proceed to the mouth. The forceps with bent points are for use in holding up the eyelids while putting in the glass eyes. Remove the tongue, and with it as much of the trachea and œsophagus as possible. Poison the mouth and throat well with the arsenical soap, and then sprinkle in a little of the powder. If there are any evident fleshy parts, chop them a little with the scalpel.

Open the skin from the tip of the sternum to the vent and push it back as far as you can conveniently. Remove the large muscles of the breast, working down to the wing; this can be done with a few strokes. Cut off as much of the loose flesh from the legs as you can conveniently. Open the abdominal cavity and with a stout hook remove the intestines. All the feathers may be protected from blood by taking a piece of tin and cutting in one side of it a deep U-shaped notch. The points of the U will fit up on each side of the bird. Several sizes of these tins will be found convenient. The intestines may be drawn out on the tin and removed. Wipe out the cavity with cotton, paint well with the soap, and then sprinkle it with the powder. Chop up the flesh at the root of the tail, and work the poison into it. After having thoroughly poisoned it, fill the body cavity with tow. Tow is preferable to cotton because wires are easily passed through it. Turn out the neck, remove the crop, œsophagus, and windpipe, hack up the flesh on the neck, and then thoroughly paint the skin and neck with the soap, and sprinkle with the powder. Your success depends on the care with which you put on the poison. Prepare two wires, one about six inches longer than the bird from head to toe, the other about the length of the bird. Pass the long wire into the bottom of one foot, up alongside the bones of the leg, just under the skin, through the body cavity, up alongside the neck, and out through the skull. Insert the second wire in the other foot in a similar way, but allow it to end in some of the bones of the body cavity. Place a little cotton in the space occupied by the crop, and begin at the neck to sew up the incision in the skin. Sew for a short distance, then fill the cavity underneath with tow or cotton. Be sure to fill it up well, for the parts will shrink some. Continue sewing until the incision is entirely closed.

With the bird on its back, spread out the wings and make an incision along the bones of each, press aside the skin, and poison the flesh well. If the bird is small, the powder is sufficient; if large, the soap should be used; and, when possible, some of the flesh might be removed. The bird is now ready to be set up, and here the method is no different from others. It will be found that, instead of the feathers on the back being displaced and ruffled, they are nice and smooth. A wire passed through the bend of one wing, through the bird and out through the bend of the other wing, then both ends bent over, will hold the wings in place.

As to time, I find that it takes me about as long to prepare a specimen this way as any, but my specimens are very much nicer. When the bird is poised, the tail and wings fastened, and the glass eyes set, there is little more to be done.

I have purposely placed some specimens thus prepared with some moth-infected birds. They have been there all summer, and, so far, are sound. If properly stuffed the specimens do not shrink and appear smaller than the original. If the muscles are well cut apart, the bird will dry just as poised. The largest bird I have tried to preserve in this manner is a great blue heron (Ardea virescens), and it dried nicely. I have several owls thus preserved. In the owls I took the brain out through the eye-socket. While large birds can be preserved in this manner, the method is better suited to small and medium-sized ones. Warblers and wrens, birds with very tender skins, are thus easily preserved. In such small birds as the warblers, only the pectoral muscle need be removed, but the others must be well chopped up and poisoned with the soap. Specimens for study, not mounted, can be nicely preserved by this process, and they are very durable.

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